ANSWERS: Fractional Distillation

1.a) Fractions:
LPG / propane / butane / methane / petroleum gas / CNG – heating / cooking / fuel / transport
Octane / petrol – fuel / transport
Paraffin – heat / light
Naphtha – chemicals
Diesel – fuel / transport
Jet fuel / kerosene – camp fuels / cooking / solvent / aeroplanes / transport
Lubricating oils – engines / waxes / polishing
Heavy oils – fuels / ships / transport
Bitumen / tar – roads / roofs.

b) i) Crude oil consists of a mixture of hydrocarbon molecules of different sizes, which need to be distilled in order to separate into useful fractions, since the fractions have different uses.

ii) A tower is used because the crude oil is heated and the hot particles rise. Hydrocarbons of different molecular masses have different boiling points. Larger molecules have higher boiling points. When the heated crude oil vapour enters the tower, the larger, heavier hydrocarbons with the higher boiling points condense into liquids lower down in the tower, while the smaller, lighter hydrocarbons with the lower boiling points rise up the tower and condense back into a liquid at the lower temperatures near the top of the tower. The smallest hydrocarbons (C1 – C4) remain gases at room temperature, and exit from the top of the tower. This allows the fractions to be separated. The temperature at which a specific hydrocarbon condenses is related to its molecular mass, particularly the number of carbon atoms. The lower / higher its molecular mass is, the lower / higher the temperature at which it will condense. This determines whereabouts on the tower the particular fraction is collected.

2. Crude oil consists of a mixture of hydrocarbon molecules of different sizes, which need to be distilled in order to separate into useful fractions, since the fractions have different uses.

Process 1 is carried out in a tall tower. The crude oil is heated and the hot particles rise.

Hydrocarbons of different molecular masses have different boiling points. Larger molecules have higher boiling points. When the heated crude oil vapour enters the tower, the **larger**, heavier hydrocarbons with the **higher boiling points** condense into liquids **lower down in the tower**, while the **smaller**, lighter hydrocarbons with the **lower boiling points** rise up the tower and condense back into a liquid at the lower temperatures **near the top of the tower**. (The smallest hydrocarbons (C1 – C4) remain gases at room temperature, and exit from the top of the tower.)

The temperature at which a specific hydrocarbon condenses is related to its molecular mass, particularly the number of carbon atoms. The **lower / higher its molecular mass is, the lower / higher the temperature (boiling point) at which it will condense**. This determines whereabouts on the tower the particular fraction is collected. Products formed during Process 1 may include: propane, butane, octane, petrol, diesel, kerosene, etc.

3. a) Crude oil consists of a mixture of hydrocarbon molecules of different sizes which need to be distilled in order to separate into useful fractions, since the fractions have different uses.
b) Fractions include: LPG (propane / butane) gas for heating and cooking; or octane / petrol and diesel for transport. Kerosene is another fuel and bitumen is used in roads.
c) A tower is used because the crude oil is heated and the hot particles rise. Hydrocarbons of different molecular masses have different boiling points. Larger molecules have higher boiling points. When the heated crude oil vapour enters the tower, the larger, heavier hydrocarbons with the higher boiling points condense into liquids lower down in the tower, while the smaller, lighter hydrocarbons with the lower boiling points rise up the tower and condense back into a liquid at the lower temperatures near the top of the tower. The smallest hydrocarbons (C1 – C4) remain gases at room temperature, and exit from the top of the tower.
The temperature at which a specific hydrocarbon condenses is related to its molecular mass, particularly the number of carbon atoms. The lower / higher its molecular mass is the lower / higher the temperature at which it will condense. This determines whereabouts on the tower the particular fraction is collected.

4. Crude oil consists of a mixture of hydrocarbon molecules of different sizes. Crude oil is heated and turned into a vapour to enter the fractionating tower. Hydrocarbons of different molecular masses have different boiling points. Larger molecules have higher boiling points. When the heated crude oil vapour enters the tower, the larger, heavier hydrocarbons with the higher boiling points condense into liquids lower down in the tower, while the smaller, lighter hydrocarbons with the lower boiling points rise up the tower and condense back into a liquid at the lower temperatures near the top of the tower. The smallest hydrocarbons (C1 – C4) remain gases at room temperature. The temperature at which a specific hydrocarbon condenses is related to its molecular mass, particularly the number of carbon atoms. The lower / higher its molecular mass is, the lower / higher the temperature at which it will condense. (This determines where on the tower the particular fraction is collected.)

5. Crude oil consists of a mixture of hydrocarbon molecules of different sizes. Hydrocarbons of different molecule masses have different boiling points. Larger molecules have higher boiling points. When the heated crude oil vapour enters the tower, the larger, heavier hydrocarbons with the higher boiling points condense into liquids lower down in the tower, while the smaller, lighter hydrocarbons with the lower boiling points condense rise up the tower and condense back into a liquid at the lower temperatures near the top of the tower. The smallest hydrocarbons (C1 – C4) remain gases at room temperature.
The temperature at which a specific hydrocarbon condenses is related to its molecular mass, particularly the number of carbon atoms. The lower /higher its molecular mass is the lower /higher the temperature at which it will condense.

6. Crude oil consists of hydrocarbons of different sizes, and thus different boiling points. The oil is heated and the smaller, lighter gases with lower boiling points are collected at the top of the tower. Other fractions with higher boiling points collect lower down, with the heaviest ones (tar) sinking to the bottom.

7. Crude oil consists of a mixture of hydrocarbons with very different boiling points due to the differences in sizes of their molecules. The oil is heated and the hot gases pass up a tower that has baffles inside it. The smaller, lighter molecules with low boiling points are collected at the top of the tower as the gas fraction. This has molecules with 1-4 C atoms per molecule. Other fractions with higher boiling points collect lower down the tower with the heaviest ones collected as tar/residue at the bottom.